Multi-Scale Model-Driven Sampling with Autonomous Systems at a National Littoral Laboratory: Turbulence Characterization from an AUV

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LONG-TERM GOAL

My long term goal is to utilize turbulence measurements obtained from small Autonomous Underwater Vehicle (AUV) based sensors as the subgrid characterization tool in combined coastal ocean observation/prediction networks.

OBJECTIVES

I wish to use AUV-based turbulence measurements to quantify mixing in shallow water physical process studies (upwelling regions, fronts. boundary layers) within the context of the LEO-15 based National Ocean Partnership Program (NOPP) coupled ocean observation/modeling system This includes estimating mixing levels, identifying regions of enhanced mixing, determining the horizontal spatial scale of mixing events, defining the role of boundary layers, and parameterizing results for coastal predictive model testing studies of subgrid scale processes.

APPROACH

My approach is to integrate an optimum turbulence sensor suite into a small, logistically simple, AUV, with input from the ocean turbulence and modeling communities. Then, I seek to establish this small AUV as a viable platform for coastal turbulence research. Towards this end, I obtain horizontals profiles of dissipation rate, temperature microstructure, 3-dimensional small scale velocity, larger scale vertical shear of horizontal current, and stratification in the coastal environment.

Subsequently, I studied mixing in the context of the multi-scale measurements surrounding the NOPP LEO-15 node site in the Mid-Atlantic Bight. I sampled adaptively using the Rutgers University continental shelf model SCRUM (Song and Haidvogel, 1994).

The sensors provided data for estimates of eddy diffusivity profile (Gargett and Moum (1995), eddy viscosity profile (using the truncated TKE equation), bulk and gradient Richardson numbers, fluxes [using the correlation technique]. These data enable us to evaluate turbulence closure schemes associated with subgrid mixing processes as parameterized by 3 different surface boundary layer submodels in SCRUM, the coastal circulation model.

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WORK COMPLETED

A turbulence sensor package was electrically and mechanically integrated into the REMUS AUV (Levine and Lueck, 1998). Sensors include two shear probes, an ultra-fast thermistor, an upward and downward looking ADCP, two CTDs, and an ADV-O. Preliminary field trials were conducted in Narragansett Bay to test sensor/platform synergy and software viability.

Utilizing these techniques, scientific studies of the Ocean Boundary Layer (OBL) during an upwelling event were conducted near the Rutgers University LEO-15 site on the inner continental shelf off New Jersey during July 1998. In the field experiment, high quality data were obtained from all sensors, and data analysis is proceeding well.

RESULTS

Using model-based adaptive sampling, the AUV was deployed along a trajectory through components of the Leo-15 upwelling region, including the upwelling gyre and offshore jet. These measurements were made synoptically with those from other platforms which characterize larger scale structures on the nearby continental shelf. Model predictions which include assimilated data from the wide variety of sampling platforms is also available for intercomparison .

Results indicate that the modified REMUS AUV (Fig 1) was a viable platform for turbulence data acquisition in the coastal ocean. For example, a data sample obtained from the vertical and transverse shear probes, for a short transect in the upwelling center during peak upwelling on July 21 1998, has been analyzed. These data have been processed to remove noise associated with vehicle vibrations. This process is done using data from accelerometers located in the probe pressure case directly behind the probe mounts, utilizing the techniques of Levine and Lueck (1998). Also, the data have been low pass filtered. The autospectra for this segment are shown in Figure 2, and correspond to a dissipation rate of approximately 5x 10^{-8} W/kg based on the computed spectral variance over the wavenumber band of the filtered data. The Nasmyth “universal spectrum” (Oakey, 1982) for this dissipation rate and appropriate viscosity agrees well in level and shape with the observations out to wavenumbers close to the physical size of the sensing tip of the shear probes.

IMPACT/APPLICATION

The AUV-based turbulence measurements provide a unique horizontal profiling view of the variability of the mixing environment that cannot be obtained by more conventionally sampling measurements, and this approach can be further exploited in yo-yoed horizontal sections. These techniques will be invaluable in upwelling process studies in which competing turbulence closure model alternatives are testing in SCRUM to parameterize subgrid processes. Competing OBL alternatives include those of Mellor-Yamada (1974) Large et al. (1994), and Price et al. (1986). Features such as the evolution of the upwelling front can be tested.

TRANSITIONS

Our AUV sensor technologies, hardware and software, are being considered for inclusion as tactical oceanography payloads for the Manta UUV Initiative, proposed for an upcoming Accelerated Research Initiative (ARI).

RELATED PROJECTS

1 My AUV-based turbulence measurement system is also being utilized in NOPP studies with the Harvard led LOOPS project. Measurements were also made in Cape Cod Bay in September 1998.

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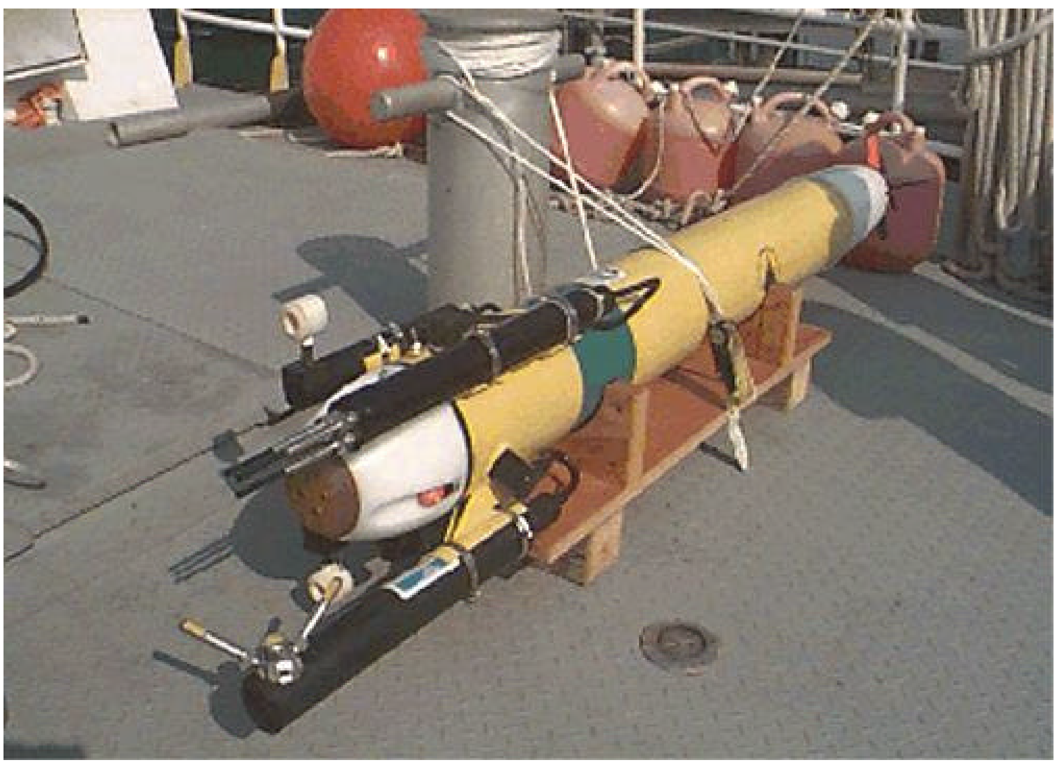

Fig. 1 The REMUS AUV instrumented with turbulence sensors

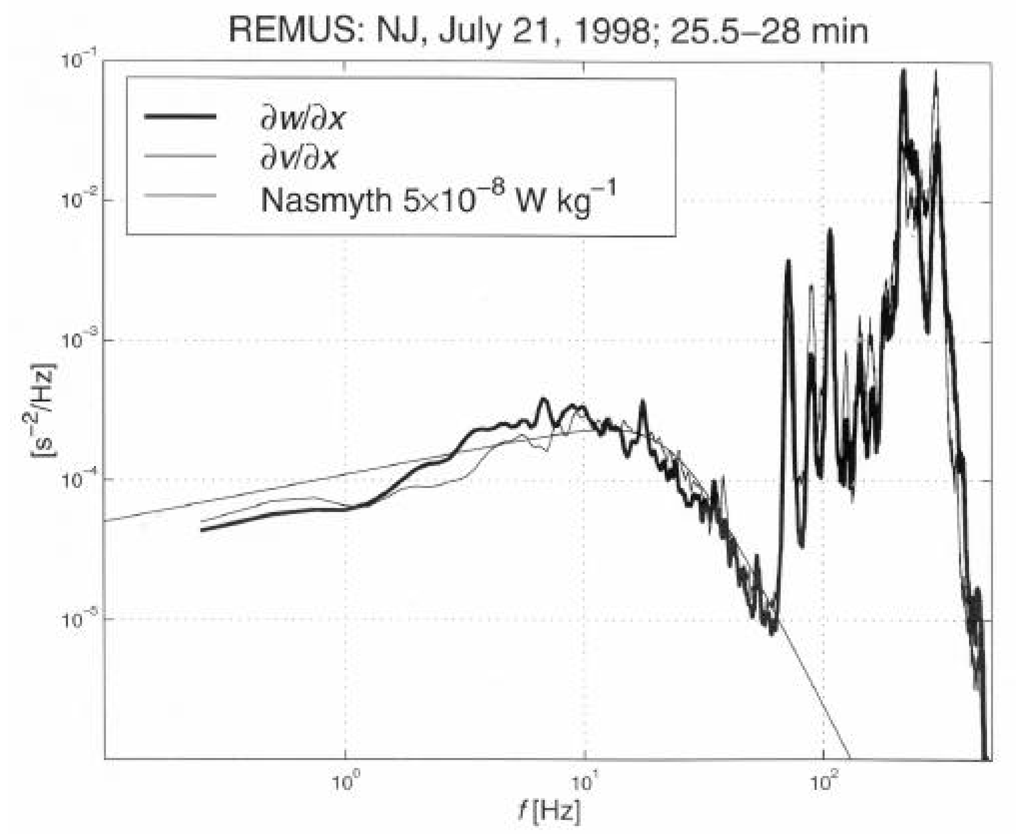

Fig. 2 A comparison of shear probe autospectra with the "Universal" spectrum